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Flood Forecasting, using Artificial Neural Network (ANN) and Predict Values of Flood condition Derived using River Water Level Data

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Abstract — This paper focuses on flood forecasting, using Artificial Neural Network (ANN) and predicts the values of flood condition derived using Narmada River Water level data of Hoshangabad (M.P). We have used the water level data as input data of ANN model for flood forecasting, and determine Standardized Water Level Index (SWLI). Artificial Neural networks operate on the principle of learning from a training set. There is a large variety of neural network models and learning procedures. Two classes of neural networks that are usually used for prediction applications are feed-forward networks and recurrent networks. They often train both of these networks using back-propagation algorithm.

Keywords—Artificial Neural Networks (ANNs), SPI

I. INTRODUCTION

Artificial intelligence (AI) is a growing trend in computer automation systems. Several types of artificial intelligence technology are available. These include robotics, voice-recognition systems, and many smart computer systems. Artificial intelligence refers to any computer system that uses a logical process to learn and improve, based on the surrounding environment and prior mistakes. This technology is undergoing a great evolution, but is still far short of the capacity of the human brain. It may take several decades before computers will can actually use logic to determine the best approach for problem solving. The current AI systems can learn, but in a limited spectrum. This is because the human brain processes thousands of variables to solve a specific problem.

II. ARTIFICIAL NEURAL NETWORK

Neural networks provide a method for extracting patterns from noisy data. We have applied them to a wide variety of problems, including cloud classification (Bankert,[2], 1994) and tornado warnings (Marzban and Stumpf,[3], 1996) in a meteorological context. We discuss the advantages and disadvantages of neural networks in comparison to other statistical techniques for pattern extraction in (Marzban and Stumpf,[3] (1996)). We can find more detail about the construction of neural networks in (Marzban and Stumpf,[3] (1996)) and (Mu̇ller and Reinhardt,[4] (1991)) and references therein. The standard procedure for use of a neural network involves ''training'' the network with a large sample of representative data. The network has some number of input and output ''nodes'' representing the predictor and predict and variables, respectively. In between, there are a number of hidden nodes arranged in layers. The number of hidden nodes and layers is usually determined empirically to optimize performance for the particular situation. Each connection between nodes on a particular layer and the layer above it can be represented by a weight, viz. that indicates the importance of that connection between the i^{th} and j^{th} nodes. The training phase of the neural network is designed to optimize the weights so that the mean-squared error of the output is minimized. For each node at a particular layer, the input node values from the previous layer are multiplied by the weight of the connections between the nodes and then all of the different connections are summed to produce the value at that node. This process is repeated for all nodes and then for each layer. The network then can be used to make predictions based on new input values.

III. USE OF ARTIFICIAL NEURAL NETWORKS (ANNs) FOR FORECASTING FLOOD CONDITION

In recent decades artificial neural networks (ANNs) have shown exceptional ability in modelling and forecasting non-linear and non-stationary time series and in most of the cases especially in prediction of phenomena have showed excellent performance.

This discussion presents the application of artificial neural networks to predict flood in Narmada River Hoshangabad (M.P). In this paper, different architectures of artificial neural networks in water level data have been used as inputs of the models. According to the results taken from this research, dynamic structures of artificial neural networks, including Recurrent Network (RN) and Time

Lag Recurrent Network (TLRN) showed better performance for this application (because of higher accuracy of its outputs). Finally, TLRN network with only one hidden layer and hyperbolic tangent transfer function was the most appropriate model structure to predict flood for the next year. In fact, by a prediction of the Flood before its occurrence, it is possible to evaluate flood characteristics in advance. It was found that ANN is an efficient tool to model and predict flood events.

Artificial Neural networks operate on the principle of learning from a training set. Two classes of neural networks that are usually used for prediction applications are feed-forward networks and recurrent networks. We often train both of these networks using the backpropagation algorithm. An advantage of backpropagation is that it is simple. Prediction networks usually take the historical measured data, and after some processing stages, future condition is simulated. In this research, after evaluation and testing of different ANN Structures, TLRN and RN we selected networks because of their higher performance, and then between these two, TLRN network showed slightly higher abilities. Therefore, TLRN was the final selected ANN type for flood prediction in this study.

IV. STUDY AREA AND DATA SOURCE

Hoshangabad:
Hoshangabad is located at 22.75°N 77.72°E.[1] It has an average elevation of 278 metres (912 feet).Northern boundary of the district is river Narmada. Across this the district of Raisen and Sehore lies. The district of Betul lies in the south, where as the Harda district faces with the western and south-western boundaries and Narsingpur and Chhindwara districts, close to the north-eastern and south-eastern sides of the district respectively. The climate of Hoshangabad district is normal. All the seasons come in the district. An average height from the sea level is 331 mts.and average rain fall is 134 cms. The average maximum and minimum temperatures are 32 deg.C and 19 deg.C respectively. Overall, the climate of the district is neither more hot nor more cool except the winter season of the Pachmarhi.

Narmada River:
The Narmada river is the longest river in Madhya Pradesh. It flows westward through a rift valley, with the Vindhya ranges sprawling along its northern bank and the Satpura range of mountains along the southern.

Its tributaries include the Banjar, the Tawa, the Machna, the Denwa and the Sonbhardra rivers. The Tapti River runs parallel to Narmada, and also flows through a rift valley. The Narmada–Tapti systems carry and enormous volume of water and provide drainage for almost a quarter of the land area of Madhya Pradesh.

The Vindhyas form the southern boundary of the Ganges basin, with the western part of the Ganges basin draining into the Yamuna and the eastern part directly into the Ganges itself. All the rivers, which drain into the Ganges, flow from south to north, with the Chambal, Shipra, Kali Sindh, Parbati, Kuno, Sind, Betwa, Dhasan and Ken rivers being the main tributaries of the Yamuna.

V. STANDARDIZED WATER LEVEL INDEX (SWI/SWLI)

In order to monitor flood in the Madhya Pradesh, the pre monsoon and post-monsoon water levels of River Narmada of the study region have been analyzed. SWI has been developed to scale the river water level. The SWI expression stands as

$$\mathbf{SWLI} = \frac{Wij - Wim}{\sigma}$$

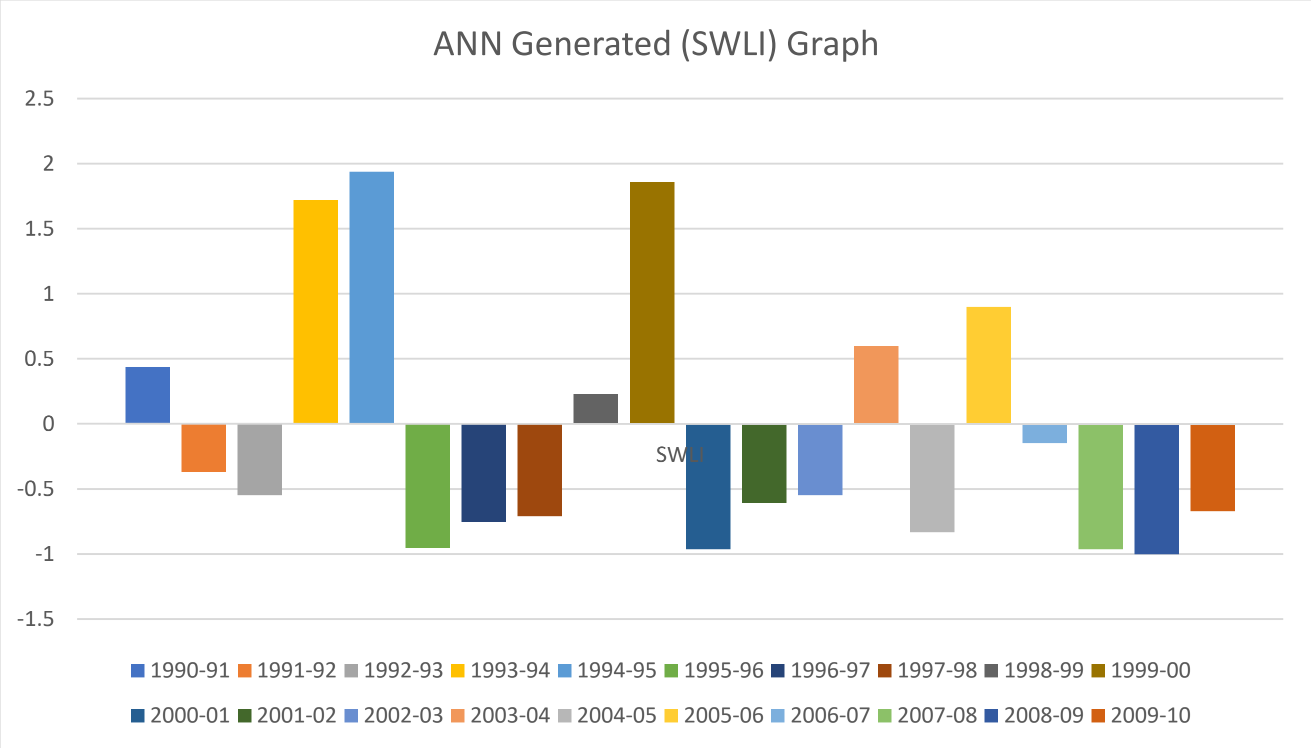
Where, Xij is the seasonal water level at the ith gauge station and jth observation, Xim is its long-term seasonal mean water level and σ is its standard deviation.

The classification of the (Flood) intensities based on the SWLI value is as follows;

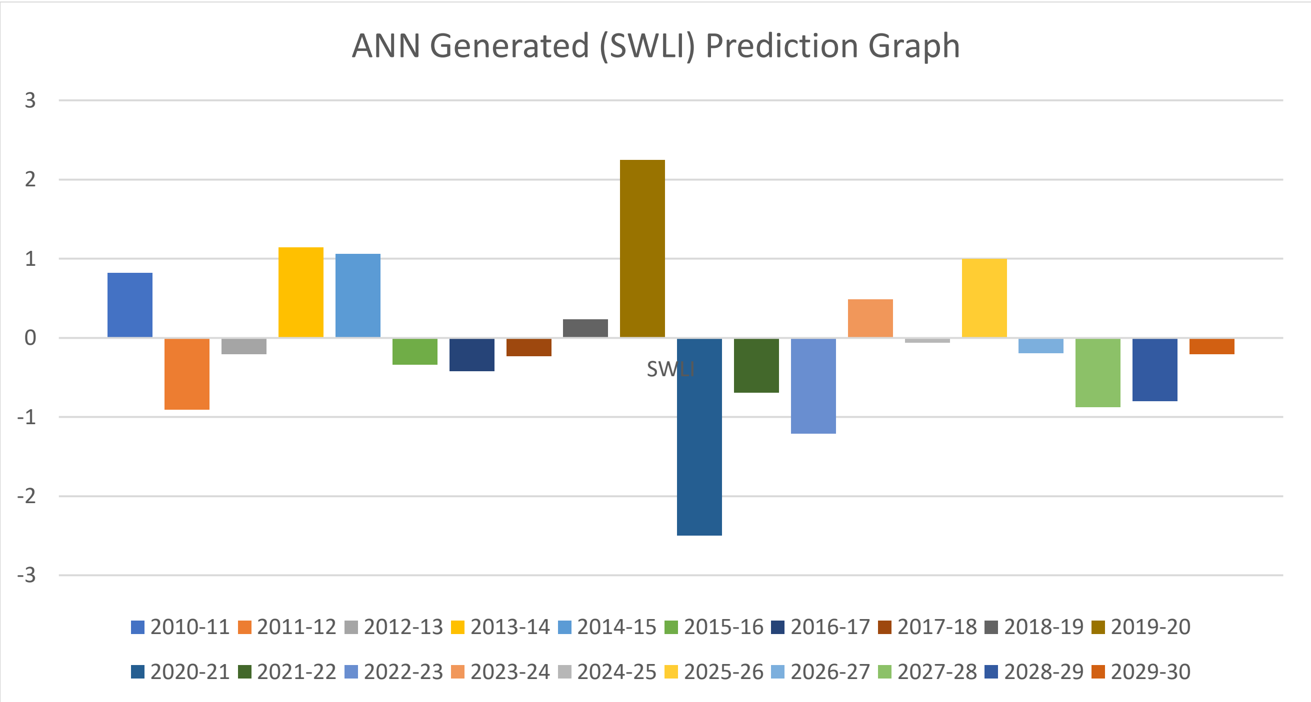
Table.1. SWLI

2.0 +	Extremely Flood
1.5 to 1.99	Severely Flood
1.0 to 1.49	Moderately Flood
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 and less	Extremely Dry

VI. ANN GENERATED (SPI) GRAPH



Graph.1. ANN Generated Actual (SWLI) Graph



Graph.2. ANN Generated Prediction (SWLI) Graph

VII. CONCLUSION

Initially, the ANN model has been conducted on the whole dataset. We have performed graphical visualization in order to make it easier to understand the data itself graph 1and 2 shows it.

The SWLI graph generates by ANN model indicate that flood appears in the Narmada River in a random fashion. From graph 1 the negative bars in years 2008-09, show over all moderate dry condition in these years and remaining years show mild dry occurrence. The positive bars in years 1990-91, 1998-99, 2003-04, 2005-06, show that good rainfall condition while in years 1993-94, 1994-95, 1999-00, show Severely Flood Condition.

Similarly, from prediction graph 2 the negative bars in years 2020-21 show extremely dry condition, while 2022-23 show moderately dry condition occurrence in these years. The positive bars in years 2010-11, 2025-26 show that good rainfall condition while in year 2019-20, shows extremely flood condition. It is observed that the actual result is very close to the predicted result in concerned area.

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